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Fast Ion Transport Studies in DIII-D High β_N Steady-State Scenarios[1]

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DIII-D research is identifying paths to optimize energetic particle (EP) transport in high β_N steady-state tokamak scenarios. Operation with $q_{min} > 2$ is predicted to achieve high β_N, confinement, and bootstrap fraction. However DIII-D experiments have shown that Alfvén eigenmodes (AE) and correlated EP transport can limit the performance of some $q_{min} > 2$ plasmas. Enhanced EP transport occurs in plasmas with $q_{min} =$2-2.5, $q_{95} =$5-7, and relatively long slowing down time. Strong AEs are present, the confinement factor $H_{89} =$1.6-1.8 and β_N is limited to ∼3 by the available power. These observations are consistent with EP transport models having a critical gradient in β_f. However, adjusting the parameters can recover classical EP confinement or improve thermal confinement so that $H_{89} > 2$. One example is a scenario with β_P and $\beta_N \approx 3.2$, $q_{min} > 3$ and $q_{95} \approx 11$ developed to test control of long pulse, high heat flux operation on devices like EAST. This has an internal transport barrier at $\rho \approx 0.7$, bootstrap fraction >75%, density limit fraction ≈1, and $H_{89} \geq 2$. In these cases AE activity and EP transport is very dynamic - it varies between classical and anomalous from shot to shot and within shots. Thus these plasmas are close to a threshold for enhanced EP transport. This may be governed by a combination of a relatively low $\nabla\beta_{fast}$ due to good thermal confinement and lower beam power, short slowing down time, and possibly changes to the q-profile. Another example is scenarios with q_{min} ≈1.1. These typically have classical EP confinement and good thermal confinement. Thus by using its flexible parameters and profile control tools DIII-D is comparing a wide range of steady-state scenarios to identify the key physics setting EP transport

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